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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 622

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. PROFESSIONAL PAPER February 2, 1918

# THE IDENTIFICATION OF VARIETIES OF BARLEY

By

HARRY V. HARLAN, Agronomist in Charge of Barley Investigations, Office of Cereal Investigations

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GOVERNMENT PRINTING OFFICE
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## VARIETIES OF BARLEY.

This bulletin has been prepared primarily to meet a widespread demand for a publication on the forms of barley. Although advantage has been taken of the opportunity to call attention to a number of new forms, the main object has been to satisfy the demand from experiment-station workers and advanced students in agronomy for an outline of the cultivated barleys. This demand can be traced to three causes—the many new forms of barley annually added to our collections, the broadening field of genetic and agronomic studies, and the confusion in and lack of availability of the literature on the forms of barley.

The increase in the number of barley varieties has been rapid. Not only have many new sorts been produced by the various agricultural experiment stations, but there has been a large number of importations. These importations have been of many types and of themselves have

done much to stimulate interest in barley. At the same time a demand for more detailed information on all our crops has developed. Plant problems, especially studies in variations and inheritance, are being persistently attacked. When this new interest was directed toward barley, it immediately became apparent that this crop, because of the unusual clearness of the varietal distinctions, was exceptionally well suited both to student instruction and to genetic studies. This clearness comes in part from the very broad limits of the group. The variable characters are numerous and the separations sharp. Few cultivated crops present such contrasts as hulled and naked kernels,[1] awned and hooded lemmas, fertile and infertile lateral florets, etc. The number of factors, coupled with the fact that all forms are perfectly fertile when crossed with each other, has resulted in a large number of easily distinguished varieties. The relative ease of subdividing the species makes the crop a profitable one to the student, and the definiteness of its varieties makes it equally useful to the plant breeder.

The lack of available literature and the confusion existing as to the identity of the various forms have been a real handicap to students and plant breeders alike. Studies in crop plants must include a comprehensive summary of the forms and types of each crop. This is a necessity for that familiarity with the crop which both student and agronomist should possess and is essential to a proper understanding of the publications of others dealing with the subject.

At present American literature contains no such summary. Indeed, the only work in English which attempts to present a complete arrangement of the forms is Beaven's "Variety of Barley" (1902).[2] This is out of print and is to be found in very few libraries. In French there are the works of Heuzé (1872, 1896–97), and in German those of Körnicke and Werner (1885), Voss (1885), and Atterberg (1899). The utilization of these and other more fragmentary publications is difficult. Frequently they are not available, and even if at the disposal of the investigator they present as many different methods of treatment as there are authors. In some instances the departures are so revolutionary that serious confusion has resulted.

The aims of this paper are (1) to coordinate the various schemes of classification and to reconcile them as far as possible, (2) to make available the work that has already been published on barley and to suggest modifications to obtain a more logical arrangement of the varieties, (3) to add the several new forms of barley which have been

[1] The word kernel is used throughout this publication to indicate the naked kernel (caryopsis) in the naked varieties and the kernel with lemma and palet attached (caryocist) in the hulled varieties. It was found too cumbersome to use the more limited terms, as they required repeated explanations.

[2] For complete citations, see "Literature cited," p. 31.

discovered during the progress of the work, and (4) to form the basis for a discussion of all the agricultural varieties grown upon the farms in America.

There is also a distinctly experimental phase to the work. Certain types of barley are likely to succeed in certain areas, while others are as definitely unsuited to specific regions. A more thorough coordination of the work of the various stations with reference to types of varieties should be of service in experimentation. It is possible also that a study of the existing forms of barley may be useful to pathologists in determining the degrees of immunity to disease of the various groups.

## REVIEW OF THE LITERATURE.

Although the genus Hordeum to which the cultivated barleys belong obtains its name direct from the Latin name, there is little to be gained in a review of the literature before Linnæus. Almost all of the pre-Linnæan authors recognized the distinction between 2-rowed and 6-rowed barleys. Linnæus (1753, p. 84–85), amplifying his scheme of 1748, described six forms, four species and two varieties, viz:

*Hordeum vulgare.*
*Hordeum vulgare coeleste.*
*Hordeum hexastichon.*
*Hordeum distichon.*
*Hordeum distichon nudum.*
*Hordeum zeocriton.*

Gustav Schuebler (1818) named seven species, using in their separation fertility, color, adherence of flowering glumes, and density. In this work he made for the first time the distinction between *nutans* and *erectum*. These were subdivisions of *distichon* and not of the rank of the seven species.

Seringe (1819) suggested four species, *hexastichon*, *vulgare*, *zeocriton*, and *distichon*. In 1841 he followed closely the scheme of Linnæus, although he made several subdivisions.

Up to and including Seringe, all treatments were based upon limited collections. As a greater number of varieties were assembled, the problem of classifying them called for a marked expansion of the systems. The first of the more modern treatments was that of Heuzé in 1872. This was really a remarkable contribution, and in both arrangement and material was the obvious forerunner of both "Die Saatgerste" of Körnicke (1882) and of the treatment in the "Handbuch des Getreidebaues" of Körnicke and Werner (1885). "Die Saatgerste," as later amplified under the title of "Die Arten und Varietäten des Getreides" in the "Handbuch des Getreidebaues" (Bd. 1), has been widely accepted as the best modern authority. In part this credit is well bestowed. Körnicke used the variety as a unit, and although he sometimes went too much into

detail, his conception of varieties was such as to establish most of them upon a firm basis. His treatment of the larger groups, on the other hand, was less satisfactory. He recognized *hexastichon*, *tetrastichum*, *intermedium*, and *distichum* as his primary groups. These are more fully discussed later. A third paper appeared in 1895, and in 1908, after his death, his son, M. Körnicke, published a fourth treatment. Neither of these latter possesses the clearness of the earlier papers, and they include many doubtful varieties. Many of the additions were of hybrid origin and were unfixed at the time of publication. Körnicke's failure in many instances was due to the general lack of genetic information at that time. Recent discoveries have made the purification of a type rather simple. For instance, his *subcornutum* was selected from a mating of *trifurcatum* and *steudelii* and was far from fixed. A constant variety of this type is readily obtained from a cross of *cornutum* × *pallidum* or of *horsfordianum* × *haxtoni*. Many varieties attributed to Körnicke in the key which follows were heterozygous forms with him which he was never able to fix. Most of these have been recognized in this publication, because fixed forms corresponding to the descriptions have since been produced.

In 1885, the year in which the "Handbuch des Getreidebaues" was published, a paper by Voss appeared. Voss follows Jessen (1855) and places all cultivated barleys under the single species *Hordeum sativum*. Although his handling of the varieties is inferior to that of Körnicke, his treatment of the larger groups is decidedly better. He uses *polystichon*, *distichon*, and *deficiens* as his subspecies. He indicates that *deficiens* is subject to the same variations as *distichon* by subdividing it into dense and lax divisions. He substitutes *inequale* for the term *tetrastichum* of Körnicke, pointing out that there is no such thing as a 4-rowed barley.

Following Voss came Atterberg, who published various papers between 1889 and 1899. In the latter year he advanced a new basis of classification. He made four subspecies under *Hordeum sativum* Jess., namely, *commune*, *macrolepis*, *furcatum*, and *inerme*. As both the character of the outer glumes and the appendages to the lemma were used, the result was rather involved and seems to offer little compensation for so abrupt a departure. Atterberg's conception of the regular occurrence of the subfactors through each of the groups gives evidence of a familiarity with a larger number of varieties than had been accessible to previous taxonomists. His system of uniform recurrence of names in his subgroups seems inadvisable and likely to lead to confusion, even though, as he points out, he uses only 33 terms to designate 188 forms, while Körnicke used 78 terms to designate 74 varieties.

Beaven in 1902 published a paper which is the most complete arrangement of barley varieties in English. He used *vulgare* in the place of the *tetrastichum* of Körnicke, divided *distichon* into dense and lax subdivisions, using *zeocriton* and *distichon* as parallel terms to *hexastichon* and *vulgare*, and classed all deficient barleys under *decipiens*. He included 45 new varieties produced by Karl Hansen. In several instances they were not sufficiently described to determine their exact character. The doubtful varieties are of necessity omitted from this paper.

The work of Regel (1906, 1908, 1910) shows more originality and less of compilation than that of most of his contemporaries. In various articles appearing in the Bulletin der Bureau für angewandte Botanik and elsewhere, he has made unquestioned contributions to the knowledge of barley. In his later publications Regel has made his finer divisions upon what might be described as ecological races, such as the Chevalier, as contrasted with the Moravian barleys. Ther is very good reason for taking this position, in that it is much less arbitrary in its relations than the usual taxonomic distinctions. It has, however, two weaknesses. Such forms, being very difficult to separate under some conditions, can be utilized only by those who have made a special study of barley, and they have no limitation to their increase in number. Almost any new barley calls for a new division, whereas under the system proposed by the present writer most additions at least will fall in a group already established. The idea of geographic forms had perhaps best be carried out as an agronomic rather than a taxonomic project. In his broader divisions Regel has combined many previously described varieties and thus broadened the terms somewhat. His modifications are well founded. He recognizes only two densities instead of three, places the smooth-awned forms under their nearest rough-awned relatives, and considers blue and purple as forms of the white variety. Carleton's (1916) major groups of *polystichon*, *distichum*, and *intermedium* differ only in the rank of the deficient barleys from the scheme proposed in this bulletin.

## VARIABLE FACTORS IN CULTIVATED BARLEY.

In cultivated barleys there are six variable characters which have been used in the description of varieties. These are fertility, adherence or nonadherence of the flowering glume, the character of the outer glumes, the character of terminal appendages to the lemma when present, color, and density. Of these, the adherence of the flowering glume and the character of the outer glumes have two conditions, the terminal appendages of the lemma and density have three conditions, and fertility and color have four conditions each. One

division of the appendages to the lemma and one of the outer glumes have been again separated into two subdivisions. The resulting number of possible varieties is in consequence very large.

### FERTILITY.

Barley, being a typical Hordeum, produces three single-flowered spikelets at each node of the rachis. In the 6-rowed forms, all three of these are fertile. In the 2-rowed only the central spikelet of each three is fertile. There are four degrees of fertility, two in the 6-rowed and two in the 2-rowed forms. The four divisions are based upon characters of the lateral florets, the central floret being the same in all. The lateral florets of normal 6-rowed barleys are completely fertile and awned or hooded. The common 2-rowed barleys are characterized by sterile lateral florets, which are awnless and normally rounded at the tip. In the intermediate barleys the side florets are fertile, but the resulting kernels are usually small and the tips are without awns. Ordinarily the lemmas are rounded, but occasionally they bear bristlelike projections. In most varieties of this group only part of the lateral florets are fertile. The fourth division is distinguished from the common 2-rowed form by a still further reduction of the side florets. This reduction may be carried to the point where only a single outer glume is present. Usually the spikelets are represented only by the outer glumes and rachilla, the floral glumes and sexual organs being entirely aborted. In some strains the lemma is present, and in a very few there are traces of the palet. Rudimentary ovaries and stamens are never found. Barleys in which sterile ovaries, rudimentary stamens, or well-developed palets appear are classed as normal 2-rowed forms.

### ADHERENCE OF THE FLOWERING GLUME.

The distinction between adherent and nonadherent flowering glumes is the sharpest and most easily determined of the six. It separates the barleys into the hulled and naked forms. In the hulled varieties the ovary grows fast to the lemma shortly before maturity. In the naked sorts this union does not take place, and when the spikes are thrashed the kernel thrashes free from the glume, as in wheat.

### OUTER GLUMES.

Each floret in barley is subtended by a pair of outer glumes. These are normally narrow, lanceolate bracts, with short, bristlelike awns. In rare cases they are expanded and the length of the awn increased. Those varieties with wide outer glumes have been further separated by some authorities, because in some instances all six of the outer glumes at a node are widened, whereas in other cases only the two

outermost of the six are so expanded. The expanded outer glume is a rare variation, which may be disregarded from an agricultural standpoint, as no such varieties are cultivated commonly.

### TERMINAL APPENDAGES OF THE LEMMA.

The lemma of either central or lateral spikelets may terminate in an awn or hood, or it may be merely rounded or pointed at the tip without either awn or hood. The hooded barleys usually are referred to in this country as beardless. Since there are true awnless sorts the term awnless is here used for these rare varieties and the term hooded for all varieties with hoods. The use of the term beardless, which is easily misunderstood, is thus avoided. The hooded varieties all appear to trace their origin to the Nepal barley. In this variety the awn is replaced by a trifurcate appendage, the three lobes of which are a partial duplication of the three florets at a node of the rachis. These monstrous florets often bear fertile stamens and are said sometimes to produce seed.

In the hooded barleys two minor separations have been made. The normal hood, as in the Nepal barley, is sessile. In many hybrids the hood is elevated more or less on an awn. Variations in the small awns sometimes produced by the hood also have been noted.

The awns of barley may be either rough or smooth. They are normally very scabrous, being much rougher than those of wheat. In a few potentially valuable agronomic forms the awns are smooth or slightly roughened at the tip. They are, however, entirely smooth toward the base, where the largest teeth are found in the rough-awned varieties. There are also a number of minor forms which bear awns considerably shorter than the normal. In others, the awn is malformed, being flattened or twisted. The difficulty of using either of these latter distinctions in other than an agronomic way is at once apparent, the one being a merging character and the last an abnormality.

### COLOR.

Four color conditions have been recognized in barley varieties. In the hulled varieties the distinction is based upon pigments located in the lemma and such aleurone and other colors as may show through the more or less translucent lemma. The naked varieties are separated on pigments found in the caryopsis, disregarding entirely the character of the lemma. In the hulled varieties the first color division is that in which no pigment is present. This results in a white or yellow barley. The second and third divisions, blue and purple, as previously pointed out (Harlan, 1914, p. 30), probably are related. The blue varieties of hulled barley come from a blue aleurone layer showing through the superimposed lemmas.

The purple colors are in the glumes themselves. The black colors come from a melaninlike pigment, which in the hulled varieties occurs in the lemmas. This may exist in different degrees and has been used to subdivide black barleys, although the advisability of separating on degree is questionable.

In the naked varieties the colors are determined more easily. The absence of pigment results in a white or yellowish grain, as in the hulled. The blue colors are located in the aleurone layer. In mature specimens they are unmistakable; in immature ones the color is slight and may give only a bluish cast, as it is deposited late in the development of the kernel. In the white varieties immaturity may result in a greenish appearance which might be confused with immature blue kernels. The purple color results from a blue aleurone layer beneath a red pericarp. In all purple varieties at present known the color is well developed except in very immature specimens and can be determined without difficulty. Black naked varieties with a true melanin pigment are very rare. Purple naked ones are usually referred to as black, although in reality they contain no black pigment and are separated easily from those having the black pigment.

### DENSITY.

Density unfortunately has been used as a major distinction in the classification of barley and usually has been confused with fertility. This is the most unsatisfactory of all the six characters. The behavior of hybrids indicates that density is determined by heritable factors, however, and further information upon its behavior may increase greatly its value as an agronomic character useful in the description of biotypes. As may be seen in Plate I, in typical forms, such as Peacock, Plumage, and Hanna, representing *zeocriton*, *erectum*, and *nutans*, respectively, the differences are marked. The intergradations are so numerous and so complete that any broad application results in confusion. Statements in taxonomic publications on barley indicate that all investigators have had great difficulty in making satisfactory separations. The groups have been divided into dense and lax varieties. In some cases the dense varieties have been further subdivided into dense and very dense groups. Körnicke in some of his treatments has divided even the very dense into two subdivisions. Such confusion is inevitable wherever separations are made upon degree, and the use of density has been confined in this paper to the description of subvarieties.

## SCHEME OF CLASSIFICATION.

A very superficial survey of the combinations that are possible with the variable factors just described is sufficient to indicate the scope

PLATE I.

SPIKES OF THREE VARIETIES OF 2-ROWED BARLEY, SHOWING THREE DEGREES OF DENSITY COMMONLY RECOGNIZED.

*A*, Peacock (*zeocriton*); *B*, Plumage (*erectum*); *C*, Hanna (*nutans*).

PLATE II.

TYPICAL SPIKES OF THE FOUR SPECIES OF CULTIVATED BARLEY.

*A, Hordeum vulgare; B, Hordeum intermedium; C, Hordeum distichon; D, Hordeum deficiens.*

of the problem to be solved. When it is realized that a great number of these forms are known and that there is no reason why all of them can not be produced, or indeed may not be found already in existence in some part of the world, the futility of continuing the policy of describing each minor variation becomes apparent. In fact, there is more to be done than merely resolving not to add to the confusion. Over 200 forms have been named and described. Some semblance of order must be brought about in the work already published and some constructive plan suggested whereby future additions may be limited to variations of real importance. When the variable characters are studied carefully with this object in view, it soon becomes apparent that the factors are not all of the same value.

The fertility and the adherence or nonadherence of the lemmas are major distinctions. They seldom present any difficulties. The nature of the appendages of the flowering glume are major distinctions so far as the distinctions between awns and hoods are concerned. The presence or absence of hoods is obvious. In the separation of varieties the term "awned" has been made to include awnless and all intergradations, as a complete series from awnless to fully awned seems likely to exist. White and black kernels are also major distinctions. White has been used to include blue and purple, because of the frequently imperfect production of the latter pigments and the difficulty of determining doubtful varieties. By using only these four groups, the varieties are founded upon distinct and readily separable characters. Each variety is then a specific, tangible group.

As lesser but still usable distinctions there are the awnless and smooth-awned variations of the awned form, the blue and purple variations of white, and the character of the outer glumes.

Besides these, a considerable number of characters have been used in establishing varieties which in the light of present information seem unsuited as bases for taxonomic groups. In many instances they are very useful in agronomic work in the description of biotypes and in the identification of farm varieties, but they are not here recognized. Varieties which have been established upon these characters will be found only in the alphabetical list of rejected forms. These characters will not be discussed individually, but will be found listed in the summary below.

To summarize the variations, the three grades of distinction are as follows:

*Major distinctions useful in establishing species and varieties:*

Spikes 6-rowed, intermediate, 2-rowed, and deficient.
Kernels hulled and naked.
Lemmas awned (including awnless) and hooded.
Kernels white (including blue and purple) and black.

*Minor distinctions useful in describing subvarieties:*

Outer glumes wide and narrow.
Lemmas awnless and smooth awned as variations of awned.
Kernels blue and purple as variations of white.

*Minor distinctions which are best used in describing agronomic biotypes* (varieties founded on these are here disregarded except in the alphabetical list):

Only two outermost glumes expanded as a variation of wide outer glumes.
Elevation of the hood on a short awn.
Small awns arising from the hood.
Flattened or twisted malformations of the awn.
Short awns, except as noted in awnless.
Character of the hairs of the rachilla.
Scabrousness of the nerves of the lemma.
Proliferation of the spike.

## THE SPECIES OF CULTIVATED BARLEY.

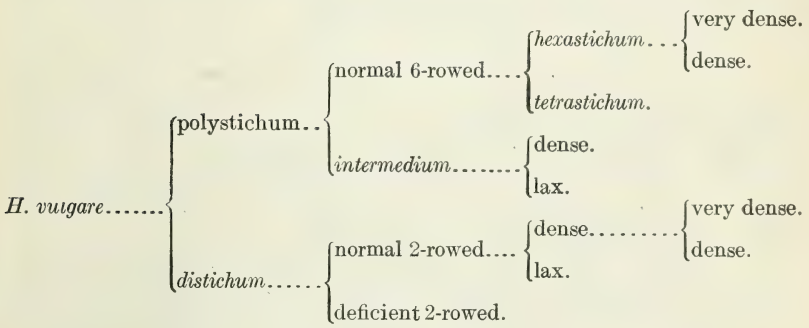
The species are of necessity based on fertility. This is predetermined essentially by the work already published, fertility having been used as a basis of separation since the earliest observations on barley.

There is no such unity of opinion in fixing the number of species. Some favor placing all cultivated barleys under a single species, as did Jessen (1855). To the writer, on the other hand, the group seems too broad to be so united. Clearness is better served by making the species a smaller unit. Certainly no group of wild plants of such variation is united under a single species, and there is abundant evidence in the behavior of hybrids that at least two parents were involved in the production of the forms now domesticated. If fertility is to be subdivided there are three bases upon which it can be accomplished. Many of the earlier writers recognize only two divisions, 2 rowed and 6 rowed. Among the modern investigators Regel takes this view. This has the disadvantage of throwing the hybrid intermediate forms with the 6-rowed, when physiologically the indications are that they are nearer the 2-rowed forms. The only way to avoid this complication is to recognize the hybrid species *intermedium* of Körnicke. We then have three grades of fertility. There are actually, however, four conditions. In one group of Abyssinian 2-rowed barley the lateral spikelets are rudimentary. Although this distinction is not as sharp as the others and needs a larger collection of Abyssinian material to determine its status clearly, there is no justification at present for rejecting the character. If three conditions are recognized, the fourth should be, which means the acceptance of the division *deficiens* as equal in value to *distichon* and *vulgare*, as suggested by Voss (1885).

The four species, *vulgare*, *intermedium*, *distichon*, and *deficiens*, shown in Plate II, seem best to represent the differences as they exist. It is not to be assumed that this is the only method of separation which might be made on the basis of fertility. Genetically the pointed or rounded nature of the lateral floret may be correlated with the true relationship of the varieties, but it would be practically impossible to use this distinction in the *deficiens* group. Neither does it fit in with work already done. On the other hand, the species founded upon fertility alone require little modification of existing schemes. As has been noted previously, many taxonomists in the past have combined and even confused fertility with density. The work of Körnicke well illustrates this point. As Körnicke is the most widely known of the investigators who have combined the two characters, his scheme is represented graphically in Table I.

TABLE I.—*Scheme of classification of barley founded upon both fertility and density.*

[Terms in italic represent Körnicke's major groups.]




It will be noted that Körnicke's major groups have very little relation to each other. Beaven (1902) remedied this defect to some extent by carrying over *zeocriton* to designate the dense normal 2-rowed, *distichon* to represent the lax, and *decipiens* to designate the deficient 2-rowed barley. His grouping, however, was not on equal separations, in that the *intermedium* and *decipiens* were separated further into dense and lax, which separations are parallel with his *zeocriton*, *distichon*, *vulgare* (*tetrastichum* Kcke.), and *hexastichon*. Although the system of Beaven was an improvement in a way, it still maintained the objectionable principle of combining the characters of density and fertility.

When the present work was begun it was thought that it would be almost impossible to maintain these well-established distinctions. However, by eliminating the density factor and retaining only the question of fertility, the four species already mentioned were obtained. This scheme is graphically represented in Table II.

TABLE II.—*Scheme of classification of barley founded upon fertility, eliminating density.*

| Genus. | Section. | Subsection. | Species. |
|---|---|---|---|
| Hordeum | vulgare | Eu. vulgare | vulgare. |
| | | intermedium | intermedium. |
| | | distichon | distichon. |
| | | | deficiens. |

KEY TO THE SPECIES.

The meaning of the graphic representation is made somewhat clearer by consulting the key to the species. It will be noted that the absence of appendages on the lateral florets is used to separate the species *intermedium*. This distinction is in reality one of fertility, the most obvious indication of which is the absence of appendages on the lemma. These lateral florets are probably not comparable to the lateral florets of *vulgare* but to the lateral florets of *distichon*, differing from the latter in having become fertile.

*Key to the species.*

All spikelets fertile (6-rowed barley).
  Lemmas of all florets awned or hooded——*vulgare* L.
  Lemmas of lateral florets bearing neither awns nor hoods.
    *intermedium* Kcke.
Only the central spikelets fertile (2-rowed barley).
  Lateral spikelets consisting of outer glumes, lemma, palet, rachilla, and usually rudiments of the sexual organs——*distichon* L.
  Lateral spikelets reduced, usually to only the outer glumes and rachilla, rarely more than one flowering glume present, and never rudiments of sexual organs——*deficiens* Steud.

Of these species the first three present no nomenclatural difficulties. *Vulgare* and *distichon* trace direct to Linnæus (1753), and *intermedium* to Körnicke (1882, p. 125). In the fourth there is more question of priority. According to Körnicke and Werner (1885), Steudel described *deficiens* in 1842. Apparently there was no published description, the identification being only the name written on a herbarium sheet of Schimper's Abyssinian collection. The name first applied appears to have been *decipiens* and not *deficiens*. In 1854 (p. 351) Steudel gives a very complete description of *deficiens* as a species. So far as the writer can learn, this is the first time the name was used in print. In May, 1842, Seringe (p. 194) in additions to the genus Hordeum describes all the common forms of deficient barley under the variety *abyssinicum*.

In the key the only question arises in the separation of the deficient 2-rowed from the normal 2-rowed barleys. Deficient types are

uncommon, and deficient barleys which show intergradations toward the normal 2-rowed are rare indeed.

In the 6-rowed barleys all awnless forms are thrown into *intermedium*. The awnless character is most probably of hybrid origin, and in all 6-rowed awnless varieties now known there is a tendency in some strains to produce short awns on the central spikelets when grown under especially favorable conditions, indicating a direct relationship with *intermedium*. It may be found necessary to include awnless sorts under *Hordeum vulgare* as well, but at present it seems better to list these forms with the *intermedium*.

Of the varieties and subvarieties which follow, a large number are of hybrid origin. The species *intermedium* probably consists entirely of hybrid varieties. In the beginning it was attempted to separate the known hybrid varieties from those occurring naturally. However, there seems no good reason for such a distinction, for many of the varieties which are not known to be hybrid probably have arisen from accidental crossing.

For example, the variety *horsfordianum* was named for a Mr. Horsford in Vermont, who crossed a Nepal (6-rowed hooded naked) on a 6-rowed bearded hulled and obtained a 6-rowed hooded hulled. This variety is grown extensively in the United States and is absolutely constant. It is inconceivable that all barley of this description in this country and elsewhere came from Mr. Horsford's cross. The Nepal has been grown in India alongside of hulled varieties for centuries, and the cross must have occurred time and again naturally, despite the fact that barley is one of the most closely fertilized of plants. It is a strange coincidence that the only natural hybrid that has occurred in the nursery in the six years of this investigation was between the Nepal and a 6-rowed bearded hulled variety, from the progeny of which a Horsford type has been isolated.

In describing varieties, fertility having been used as a specific distinction, there remain hulled or naked kernels, awned (including awnless) or hooded lemmas in the central spikelet, and white (including blue and purple) or black color as major distinctions. The first two of these characters, with the variation in width of the outer glumes later spoken of in the discussion of subvarieties, are shown in Plate III. The regularity of the gradation in differences between the varieties in each group is sufficient to excite the suspicion of the taxonomist, because such uniformity is not common in nature. Ordinarily, variations do not occur in a closely graded series. Neither did they in barley at first, but continued crossing, natural and artificial, has slowly filled the gaps.

*Hordeum vulgare trifurcatum*, for example, at first stood off clearly as the trifurcate naked 6-rowed barley. Then *horsfordianum* was produced and there were two trifurcate 6-rowed sorts, one hulled

and the other naked. Later, the trifurcate character was transferred to many forms, until *H. v. trifurcatum* is noteworthy only as the parent form of trifurcate barleys. This illustrates the vital difference between the treatment of a group with only a few representatives and one with many. The greater the number of forms, the fewer are the characters that separate them.

### KEY TO THE VARIETIES.

Following is the key to the varieties occurring under the four species of barley:

*Hordeum vulgare.* Barleys with three fertile spikelets at each node, the lemmas of both central and lateral florets bearing awns or hoods.

- Kernels hulled.
  - Lemmas awned.
    - Kernels white, blue, or purple ..... 1. *pallidum.*
    - Kernels black ..... 2. *nigrum.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 3. *horsfordianum.*
    - Kernels black ..... 4. *atrum.*
- Kernels naked.
  - Lemmas awned.
    - Kernels white, blue, or purple ..... 5. *coeleste.*
    - Kernels black ..... 6. *duplinigrum.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 7. *trifurcatum.*
    - Kernels black ..... 8. *aethiops.*

*Hordeum intermedium.* Barleys in which the lateral florets are fertile but awnless.

- Kernels hulled.
  - Lemma of central floret awned or awnless.
    - Kernels white, blue, or purple ..... 9. *haxtoni.*
    - Kernels black ..... 10. *mortoni.*
  - Lemma of central floret hooded.
    - Kernels white, blue, or purple ..... 11. *subcornutum.*
    - Kernels black ..... 12. *atricornutum.*
- Kernels naked.
  - Lemma of central floret awned or awnless.
    - Kernels white, blue, or purple ..... 13. *nudihaxtoni.*
    - Kernels black ..... 14. *nudimortoni.*
  - Lemma of central floret hooded.
    - Kernels white, blue, or purple ..... 15. *cornutum.*
    - Kernels black ..... 16. *subaethiops.*

*Hordeum distichon.* Barleys in which the lateral florets are present but sterile.

- Kernels hulled.
  - Lemmas awned or awnless.
    - Kernels white, blue, or purple ..... 17. *palmella.*
    - Kernels black ..... 18. *nigricans.*
  - Lemmas hooded.
    - Kernels white, blue, or purple ..... 19. *angustispicatum.*
    - Kernels black ..... 20. *rimpaui.*

*Hordeum distichon*—Continued.
Kernels naked.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 21. *nudum.*
Kernels black—— 22. *nigrinudum.*
Lemmas hooded.
Kernels white, blue, or purple—— 23. *laxum.*
Kernels black—— 24. *nigrilaxum.*
*Hordeum deficiens.* Barleys in which the lateral florets are not only sterile but rudimentary.
Kernels hulled.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 25. *deficiens.*
Kernels black—— 26. *steudelii.*
Lemmas hooded.
Kernels white, blue, or purple—— 27. *triceros.*
Kernels black—— 28. *tridax.*
Kernels naked.
Lemmas awned or awnless.
Kernels white, blue, or purple—— 29. *nudideficiens.*
Kernels black—— 30. *decorticatum.*
Lemmas hooded.
Kernels white, blue, or purple—— 31. *sublaxum.*
Kernels black—— 32. *gymnospermum.*

The 32 varieties described above are thought to constitute the major variations in barley. It is possible that a group of Abyssinian barleys may later be added to the intermediate forms, but it is hoped that this may be avoided. In the list of subvarieties which follows there have been no additions, although many new sorts are available. It is thought best not to add to this list of named sorts, as the large number of names is already confusing. The list of subvarieties is made up entirely of forms that have been published as varieties, but which are little more than variations of an established type. As these names have been used and as the distinctions have some foundation, even though often a fragile one, it is necessary to indicate the group each was intended to describe. It can not be too strongly recommended, however, that additions be made to the list of subvarieties only when the value of the addition is above question. At the present time the writer has in his possession blue, purple, and smooth-awned variations in a large number of new combinations. A dense form of *tonsum* has been received recently from Japan. Many dense forms of deficient barleys have been isolated from Abyssinian barley, with a complete series of colors. The addition of these to the named subvarieties seems to offer no advantages, and when they are described it will be only in a list of agronomic varieties which is expected to supplement the present publication.

KEY TO THE SUBVARIETIES.

1. *Hordeum vulgare pallidum* Seringe (1841, p. 346).
   Outer glumes narrow.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding---------- *typica.*
            Spike wide, dense, the edges parallel; awns not widely spreading---------- *parallelum* Körnicke (as var., 1882, p. 166).
            Spike wide, very dense, pyramidal, awns widely spreading. *pyramidatum* Körnicke (as var., 1882, p. 164).
         Awns smooth.
            Spike narrow, lax, nodding. *rikotense* Regel (as var., 1908, p. 74).
      Kernels bluish.
         Awns rough.
            Spike narrow, lax, nodding. *coerulescens* Seringe (as var., 1841, p. 347).
      Kernels purple.
         Awns rough.
            Spike narrow, lax, nodding. *subviolaceum* Körnicke (as var., 1895, p. 9).
   Outer glumes wide.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding. *latiglumatum* Körnicke (as var., 1895, p. 9).
            Spike wide, dense, erect. *eurylepis*, Körnicke (as var., 1882, p. 167).
2. *Hordeum vulgare nigrum* Willdenow (as sp., 1809, p. 1037).
   Outer glumes narrow.
      Awns rough.
         Spike narrow, lax, nodding---------- *typica.*
         Spike wide, dense, erect. *schimperianum* Körnicke (as var., 1882, p. 165).
      Awns smooth.
         Spike narrow, lax, nodding. *leiorrhynchum* Körnicke (as var., 1882, p. 178).
   Outer glumes wide.
      Awns rough.
         Spike narrow, lax, nodding. *atrospicatum* Körnicke (as var., 1895, p. 9).
         Spike wide, dense, erect---*platylepis* Körnicke (as var., 1895, p. 9).
3. *Hordeum vulgare horsfordianum* Wittmack (1884).
   Outer glumes narrow.
      Kernels white.
         Spike narrow, lax, nodding---------- *typica.*
         Spike wide, dense, erect. *hexasticofurcatum* K. H. in Beaven (as var., 1902, p. 577).
4. *Hordeum vulgare atrum* Körnicke (1895, p. 9).
   Outer glumes narrow.
      Spike narrow, lax, nodding---------- *typica.*
      Spike wide, dense, erect. *densifurcatum* K. H. in Beaven (as var., 1902, p. 577).

5. *Hordeum vulgare coeleste* Linnæus (as sp., 1753, p. 85).
   Outer glumes narrow.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding---------- *typica.*
            Spike wide, dense, the edges parallel, awns not widely spreading------ *revellatum* Körnicke (as var., 1882, p. 167).
            Spike wide, very dense, pyramidal, awns widely spreading. *nudipyramidatum* Körnicke (as var., 1895, p. 9).
      Kernels blue.
         Awns rough.
            Spike narrow, lax, nodding.
               *himalayense* Rittig (as var., 1822, according to Roemer and Schultes, 1824, p. 481).
      Kernels purple.
         Awns rough.
            Spike narrow, lax, nodding. *violaceum* Körnicke (as var., 1882, p. 183).
   Outer glumes wide.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding. *sublatiglumatum* Körnicke (as var., 1908, p. 425).
6. *Hordeum vulgare duplinigrum* Körnicke (1895, p. 9; modified, 1908, p. 424).
   Outer glumes narrow.
      Awns rough.
         Spike narrow, lax, nodding---------- *typica.*
7. *Hordeum vulgare trifurcatum* Schlechtendahl (1837, p. 543).
   Outer glumes narrow.
      Kernels white.
         Spike narrow, lax, nodding---------- *typica.*
8. *Hordeum vulgare aethiops* Körnicke (1895, p. 10).
   Outer glumes narrow.
      Spike narrow, lax, nodding---------- *typica.*
9. *Hordeum intermedium haxtoni* Körnicke (1882, p. 185).
   Outer glumes narrow.
      Kernels white.
         Awns rough.
            Spike narrow, lax, nodding---------- *typica.*
            Spike wide, dense, the edges parallel; awns not widely spreading---------- *transiens* Körnicke (as var., 1882, p. 185).
            Spikes wide, very dense, pyramidal, awns widely spreading. *pavoninum* Körnicke (as var., 1908, p. 429).
         Lemma of central floret awnless. *tonsum* Körnicke (as var., 1908, p. 426).
10. *Hordeum intermedium mortoni* Körnicke (1908, p. 429).
    Outer glumes narrow.
       Awns rough.
          Spike narrow, lax, nodding---------- *typica.*
       Lemma of central floret awnless. *nigritonsum* Körnicke (as var., 1908, p. 426).

11. *Hordeum intermedium subcornutum* Körnicke (1908, p. 425).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
*anomalum* Körnicke (as var., 1895, p. 10; and 1908, p. 430).

12. *Hordeum intermedium atricornutum* Körnicke (1908, p. 425).
Outer glumes narrow.
Spike narrow, lax, nodding---*typica.*

13. *Hordeum intermedium nudihaxtoni* Körnicke (1908, p. 429).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
*nuditransiens* Körnicke (as var., 1908, p. 430).
Lemma of central floret awnless.
*nuditonsum* Körnicke (as var., 1908, p. 426).

14. *Hordeum intermedium nudimortoni* var. novo. This variety was selected from the progeny of a hybrid of *haxtoni* and *nigrinudum*. It is constant, and with the other new forms described later is included here in order that the list of principal varieties may be complete. It is a variety of *intermedium* with black, naked kernels, lemmas of the central florets awned, outer glumes narrow, and spike lax and nodding.

15. *Hordeum intermedium cornutum* Schrader (1838, p. 471).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding---*typica.*
Spike wide, dense, erect.
*gymnanomalum* Körnicke (as var., 1908, p. 430).

16. *Hordeum intermedium subaethiops* Körnicke (1908, p. 425).
Outer glumes narrow.
Spike narrow, lax, nodding---*typica.*

17. *Hordeum distichon palmella* var. novo. In the common 2-rowed barleys there has apparently been no name used in recent years to include *zeocriton*, *erectum*, and *nutans*. Each of these has such a definite and specific use as a subvarietal name that it can hardly be used to include the others. Jean des Moulins in 1615, in the French edition of the work of Dalechamps (p. 333), divided the barleys into two species, *polystichon* and *distichon*. The latter he called *pomole*. Olivier de Serres, writing the same year (p. 99), used the terms *paumes* and *paumoules* for the same barleys. The *pomole* of that date was nearly identical with the group here designated *palmella*. *Pomole*, with various spellings, as *paumoule*, *pamelle*, etc., is still applied popularly to the common 2-rowed barleys in France. The name *palmella* is here used in preference, as the Latin equivalent of palm, or little palm, doubtless referring to the appearance of the spike.
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
*nutans* Schuebler (as var., 1818, p. 36).
Spike wide, dense, the edges parallel; awns not widely spreading---*erectum* Schuebler (as var., 1818, p. 36).
Spikes wide, very dense, awns widely spreading.
*zeocriton* Linnæus (as sp., 1753, p. 85).

17. *Hordeum distichon palmella*—Continued.
Outer glumes narrow—Continued.
Kernels white—Continued.
Awns smooth.
Spike narrow, lax, nodding.
*rigens* K. H. in Beaven (as var., 1902, p. 578).
Awns wanting——*inerme* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
*canescens* K. H. in Beaven (as var., 1902, p. 578).
Awns smooth.
Spike narrow, lax, nodding.
*medicum* Körnicke (as var., 1882, p. 195).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
*hypianthinum* Körnicke (as var., 1895, p. 10).
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
*dubium* Körnicke (as var., 1908, p. 431).
Spike wide, dense, erect.
*macrolysis* K. H. in Beaven (as var., 1902, p. 578).
18. *Hordeum distichon nigricans* Seringe (1842, p. 357).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, the edges parallel, awns not widely spreading.
*contractum* Körnicke (as var., 1882, p. 198).
Spike wide, dense, erect, awns widely spreading.
*melanocrithum* Körnicke (as var., 1882, p. 200).
Awns smooth.
Spike narrow, lax, nodding.
*persicum* Körnicke (as var., 1882, p. 196).
Awns wanting.
*decussatum* Körnicke (as var., 1895, p. 8).
Outer glumes wide.
Awns rough.
Spike narrow, lax, nodding.
*braunii* Körnicke (as var., 1882, p. 202).
Spike wide, dense, erect.
*mixtum* K. H. in Beaven (as var., 1902, p. 578).
19. *Hordeum distichon angustispicatum* Körnicke (1895, p. 11).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding——*typica.*
Spike wide, dense, the edges parallel, awns not widely spreading.
*latispicatum* Körnicke (as var., 1895, p. 11).
Spikes wide, very dense, awns widely spreading.
*furcatozeocriton* K. H. in Beaven (as var., 1902, p. 578).

19. *Hordeum distichon angustispicatum*—Continued.
Outer glumes narrow—Continued.
Kernels purple.
Spike narrow, lax, nodding.
*koernickei* K. H. in Beaven (as var., 1902, p. 579).
20. *Hordeum distichon rimpaui* Wittm. (Körnicke, 1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding.....*typica*.
21. *Hordeum distichon nudum* Linnæus (1753, p. 85).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.....*typica*.
Spike wide, dense, the edges parallel; awns not widely spreading.....*neogenes* Körnicke (as var., 1895, p. 10).
Spike wide, very dense, awns widely spreading.
*gymnocrithum* Körnicke (as var., 1895, p. 10).
Awns wanting.....*duploalbum* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
*rossii* Körnicke (as var., 1895, p. 10).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
*ianthinum* Körnicke (as var., 1895, p. 10).
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
*nudidubium* Körnicke (as var., 1908, p. 431).
22. *Hordeum distichon nigrinudum* var. novo. This form was isolated in 1909 from an importation of Abyssinian barleys. Two naked seeds were found, which were so black that they appeared to have been charred. They proved viable, however, and have since produced coal-black seeds. In other respects the variety corresponds to *nudum*.
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding.....*typica*.
Awns wanting.....*duploatrum* Körnicke (as var., 1895, p. 8).
23. *Hordeum distichon laxum* Körnicke (1895, p. 7).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding.....*typica*.
Spike wide, dense, erect.....*densum* Körnicke (as var., 1895, p. 11).
24. *Hordeum distichon nigrilaxum* var. novo. This variety was produced from a cross of *horsfordianum* and *nigrinudum*. It is a 2-rowed, hooded barley of the species *distichon*, with naked black seeds, outer glumes narrow, spike narrow, lax, nodding.
25. *Hordeum deficiens deficiens* Steudel (1854, p. 351).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.....*typica*.

25. *Hordeum deficiens deficiens*—Continued.
Outer glumes wide.
Kernels white.
Awns rough.
Spike narrow, lax, nodding.
*rehmii* Körnicke (as var., 1895, p. 10).
Spike wide, dense, erect—*abyssinicum* Seringe (as var., 1842, p. 194; modified, Körnicke, 1882, p. 202).
Awns wanting—*subinerme* Körnicke (as var., 1895, p. 8).
Kernels bluish.
Awns rough.
Spike narrow, lax, nodding.
*pseudoabyssinicum* Körnicke (as var., 1908, p. 432).

26. *Hordeum deficiens steudelii* Körnicke (1882, p. 206).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns smooth.
Spike narrow, lax, nodding.
*subglabrum* K. H. in Beaven (as var., 1902, p. 579).
Awns wanting—*subdecussatum* Körnicke (as var., 1895, p. 8).
Outer glumes wide.
Awns rough.
Spike narrow, lax, nodding.
*macrolepis* A. Br., (as var., 1848, according to Körnicke, 1885, Bd. 1, p. 185).
Awns smooth.
Spike narrow, lax, nodding.
*leiomacrolepis* Regel (as var., 1908, p. 78).

27. *Hordeum deficiens tricolor* Körnicke (1895, p. 11.)
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding—*typica.*

28. *Hordeum deficiens tridax* Körnicke (1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding—*typica.*

29. *Hordeum deficiens nudideficiens* Körnicke (1895, p. 11).
Outer glumes narrow.
Kernels white.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns wanting—*subduplialbum* Körnicke (as var., 1908, p. 434).
Kernels purple.
Awns rough.
Spike narrow, lax, nodding.
*viviscens* K. H. in Beaven (as var., 1902, p. 579).

30. *Hordeum deficiens decorticatum* Körnicke (1895, p. 11).
Outer glumes narrow.
Awns rough.
Spike narrow, lax, nodding—*typica.*
Awns wanting—*subdupliatrum* Körnicke (as var., 1908, p. 434).

31. *Hordeum deficiens sublaxum* Körnicke (1908, p. 433).
Outer glumes narrow.
Kernels white.
Spike narrow, lax, nodding ..... *typica.*
32. *Hordeum deficiens gymnospermum* Körnicke (1895, p. 11).
Outer glumes narrow.
Spike narrow, lax, nodding ..... *typica.*

### REJECTED SPECIES, SUBSPECIES, AND VARIETIES.

In the analysis of the relative value of the variable characters of barley, a number of variations were regarded as of too minor a nature to be used even in the description of named subvarieties. These included the elevation of the hood on a short awn, awns produced on the hood itself, malformed awns, short awns, the nature of the hairs on the rachilla, the toothing of the nerves of the lemma, and the widening of only the two outermost glumes at a node. Varieties established upon these characters are not recognized in the key. Inasmuch as the names often appear in papers on barley, a statement of the nature of the variation is necessary for reference use. For this reason an alphabetical list of discarded species and varieties has been prepared. A few groups founded on other bases have been included. The most important of these is probably that of compound spikes. The inclusion of compound spikes as a recognized character would simply double the number of varieties. In barley, proliferation of spikes is common, but in most strains it is not inherited. In others, while the tendency is transmitted, it is inherited imperfectly. Even if it were perfectly heritable its use would offer little of advantage. The list also contains various synonyms which have been published from time to time. In a few instances names occur both in the key and in the list of rejected forms. In these cases the names have been used in two or more ways and in the misapplied use appear here. Where the form is compared with one in the key, it bears the key number of the recognized variety.

#### ALPHABETICAL LIST OF REJECTED SPECIES, SUBSPECIES, AND VARIETIES.

*abyssinicum* Seringe (1842, p. 194, as. var.), as originally described equal to the species *deficiens.*

*aegiceras* Royle (1839, p. 418), synonym for *H. v. trifurcatum* (7).

*aethiopicum* Alefeld (1866, p. 343), synonym for *H. distichon nigricans* (18).

*albidum* Körnicke (1873, p. 4), synonym for *H. v. pallidum* (1).

*angustissimum* Körnicke (1908, p. 432, as var.), synonym for *H. distichon laxum* (23).

*atratum* K. H. in Beaven (1902, p. 597, as var.), synonym for *H. deficiens steudelii* (26).

*atterbergianum* Regel (1908, p. 77, as var.), synonym for *H. deficiens steudelii subglabrum* (26).

*atterbergii* Körnicke (1895, p. 10, as var.), *H. distichon palmella nutans* (17), with lateral florets enlarged and pointed.

*brachytherum* Körnicke (1882, p. 164, as var.), short-awned form of *H. v. pallidum pyramidatum* (1).

*brachyura* Alefeld (1866, p. 340), very dense form of *H. v. pallidum pyramidatum* (1).

*beijerinckii* Körnicke (1908, p. 431, as var.), *H. distichon palmella macrolysis* (17), with only the two outermost glumes expanded.

*coelestoides* Seringe (1841, p. 358), synonym for *H. distichon nudum* (21).

*commune* Atterberg (1899, p. 7), used as a subspecies to designate all barleys with narrow glumes and awned central florets.

*compactum* Körnicke (1908, p. 424, as var.), synonym for *H. v. horsfordianum hexasticofurcatum* (3).

*complanatum* K. H. in Beaven (1902, p. 577, as var.), synonym for *H. i. subcornutum anomalum* (11).

*compositum* Körnicke (1882, p. 206, as var.), compound form of *H. distichon palmella nutans* (17).

*crispicapillum* Körnicke (1895, p. 10, as var.), compound form of *H. v. coeleste* (5).

*crispum* Körnicke (1895, p. 4, as var.), compound form of *H. v. pallidum* (1).

*cucullatum* Körnicke (1882, p. 179, as var.), a malformation of *H. v. horsfordianum* (3).

*densum* Seringe (1841, p. 345 and 357), used for subvarieties under both *hexastichon* and *distichon.*

*densum* Voss (1885, p. 280), used to include all dense, narrow-glumed, deficient barleys.

*eingens* K. H. in Beaven (1902, p. 579, as var.), synonym for *H. distichon rimpaui* (20).

*erectonudum* K. H. in Beaven (1902, p. 578, as var.), synonym for *H. distichon nudum neogenes* (21).

*falsum* Atterberg (1899, p. 11), used to designate all varieties with horseshoe-shaped depression at base of grain.

*flaccidum* Voss (1885, p. 279, as var.), included lax forms of *H. v. coeleste* (5).

*furcatum* Atterberg (1899, p. 7), used as subspecies, including all hooded forms with linear outer glumes.

*genuinum* Alefeld (1866, p. 340), synonym for *H. vulgare*, used as *H. v. genuinum.*

*genuinum* Eriksson (1899, p. 2), a lax subdivision of *H. distichon palmella erectum* (17).

*gracilius* Körnicke (1882, p. 167, as var.), synonym for *H. v. nigrum schimperianum* (2).

*heterolepis* Körnicke (1882, p. 202, as var.), *H. distichon palmella macrolysis* (17), with only the two outermost glumes expanded.

*heuzei* Körnicke (1882, p. 170, as var.), *H. v. pallidum* (1), with malformed awns approaching hoods.

*hexastichum* Linnæus (1753, p. 85, as sp.), all dense forms of *H. vulgare.*

*hibernum* Heuzé (1872, p. 454), winter forms of *H. v. pallidum pyramidatum.*

*imberbe* Lamarck and Candolle (1815, p. 93), a form of *H. distichon palmella erectum* (17) with deciduous awns.

*inaequale* Voss (1885, p. 278), group term to include all lax *vulgare*.

*inerme* Atterberg (1899, p. 7), used as subspecies including all awnless varieties.

*krausianum* Wittmack (1885, p. 1), compound form of *H. distichon palmella erectum* (17), with some naked grains.

*laxifurcatum* K. H. in Beaven (1902, p. 578, as var.), synonym for *H. v. atrum* (4).

*laxum* Seringe (1841, p. 344 and 356), used to designate lax varieties under both *hexastichon* and *distichon*.

*laxum* Voss (1885, p. 281), including all lax deficient barleys with narrow glumes.

*macrolepis* Atterberg (1899, p. 7), used as subspecies, including varieties with wide outer glumes on the central spikelet.

*macroteron* Alefeld (1866, p. 340), less dense forms of *H. v. pallidum pyramidatum* (1).

*monstrosum* K. H. in Beaven (1902, p. 579, as var.), synonym for *H. deficiens gymnospermum* (32).

*muticum* Hoffmann (1877, p. 272), probably deciduous *H. distichon palmella* (17).

*muticum* Atterberg (1899, p. 8), as subspecies, including all varieties with large flowering glumes in lateral spikelets, whether fertile or infertile.

*nigrescens* Körnicke (1882, p. 195, as var.), a brown form of *H. distichon nigricans* (18).

*nudiramosum* K. H. in Beaven (1902, p. 578, as var.), compound form of *H. v. coeleste* (5).

*parvihamatum* K. H. in Beaven (1902, p. 579, as var.), short-awned form of *H. distichon angustispicatum* (19).

*patens* Eriksson (1889, p. 2), dense subdivision of *H. distichon palmella erectum* (17).

*platylepis* Voss (1885, p. 281), included all dense, wide-glumed *deficiens* barleys.

*polystichon* Haller (1776, p. 5), synonym for *tetrastichum* Körnicke, all lax *vulgare*.

*polystichon* Döll (1857, p. 119), all 6-rowed barleys.

*pseudotrifurcatum* Langsdorff (1860, p. 9), a form of *H. v. trifurcatum* (7) carrying a short awn.

*ramosum* Seringe (1841, p. 358), a compound *distichon*.

*ramosum* Hochstetter (1848, p. 147), a compound form of *H. deficiens* (25).

*ramulosum* K. H. in Beaven (1902, p. 579, as var.), a compound form of *H. distichon nudum* (21).

*recens* Körnicke (1882, p. 167, as var.), only two outermost glumes expanded, otherwise as *H. v. pallidum eurylepis* (1).

*rectum* Voss (1885, p. 278), dense forms of *H. v. coeleste* (5).

*rostratum* Atterberg (1899, p. 9), as *muticum*, except that the awnless spikelets of the former bear hairlike awns.

*sativum* Jessen (1855), used as a single species to include all cultivated barleys.

*schweinfurthii* Körnicke (1908, p. 420, as var.), synonym for *H. distichon nigricans* (18).

*serratum* K. H. in Beaven (1902, p. 579, as var.), synonym for *H. deficiens sublaxum* (31).

SPIKES OF FOUR FORMS OF BARLEY, SHOWING SEVERAL COMMON CHARACTERS.

*A*, *Hordeum vulgare trifurcatum*; *B*, *Hordeum vulgare coeleste violaceum*; *C*, *Hordeum intermedium haxtoni tonsum*; *D*, *Hordeum vulgare pallidum curylepis*. Of these forms, *A* is hooded, *B* and *D* awned, and *C* awnless; *A* and *B* are naked, *C* and *D* hulled; *A*, *B*, and *C* have narrow outer glumes, and *D* wide outer glumes.

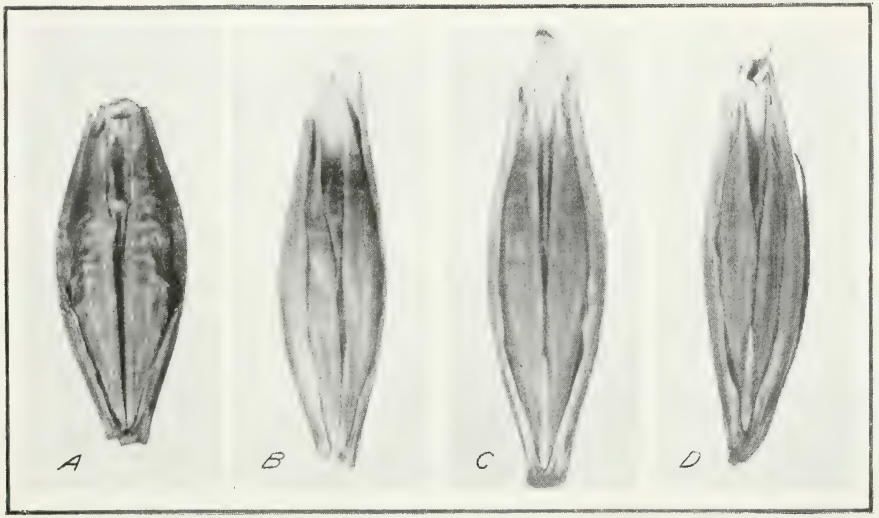



FIG. 1.—KERNELS OF 2-ROWED (A) AND 6-ROWED (B, C, AND D) BARLEYS.

The lateral kernels (*B* and *D*) of the 6-rowed barleys are twisted.

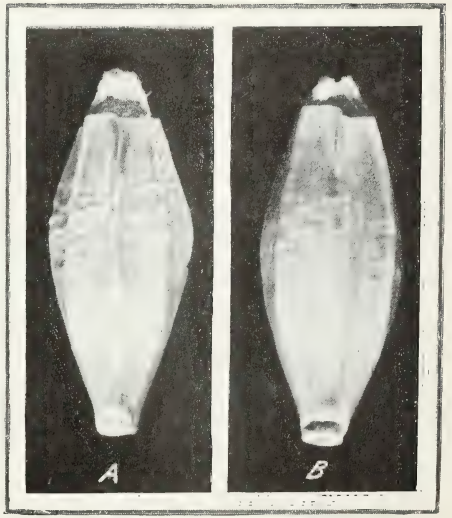



FIG. 2.—KERNELS OF LAX AND DENSE BARLEYS.

*A* shows the horseshoe-shaped depression at the base of the lax varieties and *B* the transverse crease usually occurring at the base of the erect varieties.

*scringei* Körnicke (1882, p. 206, as var.), a brown form of *H. deficiens steudelii* (26).

*subatterbergii* Körnicke (1908, p. 430, as var.), synonym for *H. i. nudihaxtoni nuditransiens* (13).

*subcompositum* Körnicke (1908, p. 434, as var.), a compound form of *H. distichon nudum* (21).

*subhaxtoni* Körnicke (1908, p. 429, as var.), an indefinite variation of *H. i. nudihaxtoni* (13).

*spurium* Atterberg (1899, p. 11), varieties with neither crease nor depression at base of grain.

*tetrastichum* Körnicke (1822, p. 125), all lax *vulgare*.

*tortile* Seringe (1841, p. 349), a 6-rowed barley with malformed awns approaching hoods.

*tortile* Robert (1832, according to Seringe, 1841, p. 349), probably as above.

*tortilis* Heuzé (1872, p. 457), probably as *tortile* Ser.

*triangulare* Körnicke (1908, p. 432, as var.), synonym for *H. distichon angustispicatum furcatozeocriton* (19).

*utriculatum* K. H. in Beaven (1902, p. 579, as var.), synonym for *H. distichon laxum* (23).

*verum* Atterberg (1899, p. 11), all varieties with transverse crease at base of grain.

*violascens*, K. H. in Beaven (1902, p. 578, as var.), synonym for *H. distichon palmella canescens* (17).

*walpersii* Körnicke (1882, p. 182, as var.), synonym for *H. v. coeleste* (5).

## LINES FOR FURTHER STUDY.

The various characters upon which varieties have been founded have been discussed in connection with the keys and lists of varieties. Between most of the characters retained in the keys, the distinctions are quite sharp. There are a few, however, which are not exactly clear and which offer attractive fields for study.

The question of color is not on an entirely satisfactory basis. Colors are apparently the results of minor phases of metabolism, but have been utilized in taxonomic work because of the fact that they are conspicuous. Doubtless many more important features of metabolism are ignored in the grouping of varieties. Being a question of metabolism, and usually one of the altered metabolism of approaching maturity, it is questioned whether environment may or may not affect the production of pigment. This is particularly worthy of study in the blue and purple colors.

The variations of density are equally suggestive. There is no apparent reason why a strain of any given density can not exist, and in the grouping of varieties it would be worth while to know if there is even a narrow gap between the dense and lax forms. Possibly density, which has here been reduced to a subvarietal distinction, may have to be eliminated altogether. The separation of *deficiens* and *distichon* also presents possible difficulties. Hybrids of *deficiens*

and *distichon* do not fall clearly into the two groups of their parents. How much the heterozygous character is responsible for the confusion remains to be determined. How broad the interpretation of *intermedium* should be is also a matter of doubt. It may be that it should include forms in which the lateral florets are sterile but pointed. This would explain such forms as *atterbergii* Ecke., which most probably are genetically nearer *intermedium* than *distichon*, even though the pointing of the glume is a glume character and not one of fertility.

## IDENTIFICATION OF THRASHED MATERIAL.

Of necessity the keys have been based on spike characters. Frequently, however, it is necessary to identify a barley from thrashed kernels alone. This is not always possible, but ordinarily the chance of error is negligible, owing to the fact that only one of the series of possibilities may with any likelihood occur under a given set of conditions. The observations to be made are taken up in the order in which they occur in the key.

By means of fertility only the first three species can be identified. *Deficiens* can not be separated from *distichon* with certainty on the basis of the grain alone. It may well be ignored, however, because varieties of *deficiens* are rare. They occur naturally only in Abyssinia and Asia Minor. In the United States they are found on few of our experimental stations and are almost unknown on farms. The first determination is usually as to whether the sample is 2 rowed or 6 rowed. This can be ascertained readily by the presence or absence of the lateral kernels in the sample. If it is 2 rowed, of course there will be no lateral kernels. As shown in Plate IV, figure 1, these lateral kernels can be identified by the twisted character. On the spike their bases lie almost in the same plane as that of the central kernel. Toward the tip, however, they gradually turn inward until the planes of the furrows approach a right angle. When the kernel is laid upon the dorsal side, this twist of the furrow is quite conspicuous. The species *intermedium* usually can be disregarded, because of the fact that it occurs very rarely. However, it is separated easily from *vulgare*. The lateral kernels are not only smaller than those of *vulgare*, but the tips are either rounded or (somewhat rarely) pointed, showing that neither awn nor hood had been present in the spike.

The adherence of the flowering glume is, of course, more apparent in the thrashed grain than in the spike itself, as the hulled and naked barleys are most easily identified by thrashing. The determination can be made, however, without injury to herbarium material, for the fine cross wrinkling never occurs on the lemmas of the naked forms, and the freedom of the glumes is itself apparent at the juncture of the lemma and palet.

The color of the grain is also as apparent in thrashed material as in the spike. The determination of the awned or hooded character is next to impossible if the sample has been thrashed clean. Ordinarily enough kernels still bear fragments of awns or hoods, as the case may be, to make this determination certain. If the barley has been clipped, the determination may be impossible. Naked varieties are more difficult to determine than hulled, and the identification must depend upon the fragments of awns and hoods which are likely to be present. Short, relatively thick kernels may be suspected of being the Nepal, which is the hooded, white, 6-rowed naked barley, but positive identification can not be made on this basis alone.

These characters carry the identification as far as the variety. If it is desired to determine the subvariety, it is necessary to establish the minor variations. This is not always possible, but fortunately the most common variations are the easier to determine. The more rare variations may be ignored with safety in 99 per cent of the samples. The varieties with wide outer glumes can not be separated from those with narrow glumes unless internodes from the rachis are present with the outer glumes attached. This is usually the case; but even if it were not, there is small chance of a wide-glumed variety being present.

Any difficulty encountered in the determination of color is usually confined to the separation of blue and white. As the blue color in hulled barleys is located in the aleurone layer, it is best to strip the lemmas from two or three grains, for weathering often so discolors them that it is impossible to see the blue color beneath. Purple color in these varieties is found in the glumes. In naked varieties the color is more readily seen, but is difficult of determination in immature specimens. Until well ripened, some white varieties have a greenish cast which might easily be confused with the blue. The blue and purple do not develop until near maturity. In blue barleys especially the color may be very pale. In well-matured specimens, however, there is little difficulty in making the determination.

The smoothness or roughness of the awns can be told if fragments of awns persist on any of the kernels. If the lateral nerves of the lemma are very scabrous, it may be taken for granted that the awns were rough. Smooth-awned varieties are so rare, however, that this may be disregarded.

Density usually can be determined from thrashed specimens, although not with absolute certainty. In extreme cases the identification is made easily. As shown in Plate IV, figure 2, there is a transverse crease at the base of the lemma in the dense varieties. In the lax ones there is a small horseshoe-shaped depression. The dense varieties of 6-rowed barley usually have the base of the lemma elongated, especially in the lateral florets. In most varieties of *inter-*

*medium* this extension is characteristic of the lateral florets of lax varieties as well. In barleys with awnless lateral kernels the observation should be made upon the central kernel. In the naked varieties density can not be determined with certainty from thrashed specimens.

## VARIETIES GROWN IN FIELD CULTURE IN THE UNITED STATES.

Students and experimenters usually are interested in the variation that occurs in a crop as a whole, but there are also times when they are concerned only with local forms. For this reason it has been thought advisable to include a short list of the varieties and subvarieties which are grown in field culture in the United States. Although a very small percentage of the total number of forms is to be found, they are distributed through the groups in such a way as to be quite representative. The only forms which are entirely lacking are the deficient, wide-glumed, and smooth-awned varieties and subvarieties. The wide-glumed forms are not found in pure culture even at our experiment stations. Deficient barleys are grown at but few stations, and smooth-awned varieties at even a less number. The writer has a considerable number of smooth-awned selections in field tests in cooperation with the Minnesota Agricultural Experiment Station and elsewhere. *Hordeum vulgare pallidum* and *H. distichon palmella* include most of the agronomic varieties grown. The greater proportion of varieties in each case is found in the lax subdivisions. The following key includes a few well-known agronomic varieties in each of the more common subvarieties.

### KEY TO COMMERCIAL VARIETIES.

Spikelets all fertile (6-rowed barleys).
  Lateral florets awned or hooded (sp. *vulgare*).
    Kernels hulled.
      Lemmas awned.
        Kernels white, blue, or purple (var. *pallidum*).
          Kernels white.
            Spike narrow, lax, nodding ..... subvar. *typica*.
            Represented by the agricultural varieties Manchuria, Oderbrucker, Tennessee Winter, and white strains of Coast (Bay Brewing), etc.
            Spike wide, very dense, pyramidal, awns widely spreading ..... subvar. *pyramidatum*.
            Represented by the agricultural varieties Winter Club (White Winter or Utah Winter), Tapps Winter, and Mariout.
          Kernels blue ..... subvar. *coerulescens*.
            Represented by blue-gray strains of Coast and several pedigreed selections of Manchuria.
        Kernels black ..... var. *nigrum*.
          Represented by the agricultural variety Gatami.

Spikelets all fertile (6-rowed barleys)—Continued.
Lateral florets awned or hooded (sp. *vulgare*)—Continued.
Kernels hulled—Continued.
Lemmas hooded——var. *horsfordianum*.
Represented by the agricultural variety Horsford Beardless (Success Beardless).
Kernels naked.
Lemmas awned.
Kernels white, blue, or purple (var. *coeleste*).
Kernels white——subvar. *typica*.
Represented by Jerusalem barley and other naked varieties, usually not named.
Kernels blue——subvar. *himalayense*.
Represented by the agricultural variety Himalaya Hull-less (Guy Mayle).
Kernels purple——subvar. *violaceum*.
Represented by the agricultural variety Black Hull-less.
Lemmas hooded——var. *trifurcatum*.
Represented by the agricultural variety Nepal (White Hull-less).
Lateral florets rounded or pointed, neither awned nor hooded (sp. *intermedium*).
Kernels hulled.
Lemma of central floret awned or awnless (var. *haxtoni*).
Lemma of central floret awnless——subvar. *tonsum*.
Represented by the agricultural varieties Arlington Awnless, Famesh, and in the dense form by Nakano Wase.
Central spikelets only fertile, lateral sterile or wanting (2-rowed barley).
Lateral florets present (sp. *distichon*).
Kernels hulled.
Lemmas awned.
Kernels white, blue, or purple (var. *palmella*).
Kernels white.
Spike narrow, lax, nodding——subvar. *nutans*.
Represented by the agricultural varieties Hanna, Hannchen, Moravian, Princess, Chevalier, etc.
Spike wide, dense, erect——subvar. *erectum*.
Represented by the agricultural varieties Svanhals, Primus, Goldthorpe, etc.
Kernels black——var. *nigricans*.
Represented by the agricultural varieties Black Smyrna and Black Arabian.
Kernels naked.
Lemmas awned.
Kernels white——var. *nudum*.
Represented by the agricultural variety McEwans, etc.

No attempt has been made in the above key to distinguish between the agronomic varieties within a subvariety. It is hoped to make

these separations in a later publication. In the varieties at present grown in America, separations are most difficult in the lax forms of the common 6-rowed barleys. In general, there are two groups, the Manchuria-Oderbrucker and the Coast. These groups are separated by the longer, heavier grain and the more tenacious awn of the latter. Within a group such as the Manchuria, identifications must be based on combinations of minor characters, such as the density of the spike, the nature of the hairs on the rachilla, the length of grain, and, if necessary, distinctive culm characters and the length of the growing season.

## SUMMARY.

The variations that occur in barley are of importance to the student, agronomist, plant breeder, and pathologist. They offer a wide opportunity for selection, breeding, and studies of disease resistance. In barley the forms are unusually numerous and clearly defined. The number and character of the types existing are more concisely indicated by a classification of variations than in any other way.

The groups of barley have been arranged upon the basis of species, varieties, and subvarieties. Only major characters have been used in describing species and varieties; less important characters have been utilized in describing subvarieties. Under each subvariety there may be an unlimited number of agronomic varieties. Four species and 32 varieties are recognized.

All groups have been made to conform with previous usage as far as possible. One of the principal aims of the writer of this bulletin has been to state clearly the form or group intended to be described by each published name. Except for their historical significance, the subvarieties would not have been continued, and no forms have been added to them.

Four varieties have been added.

Lists of rejected terms and varieties are included.

The keys can be adapted to the identification of thrashed grain by a number of characters. In the common agronomic varieties the chance of error in the identification of thrashed grain is slight.

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